Hamlet of Cambridge Bay, NU
Waste Facility Improvements
(GN Project No. 04-4807)
Detailed Design Report for Redevelopment of Existing Waste Facilities

Prepared for:
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1.0 INTRODUCTION

1.1 Project Background

Earth Tech was retained by the Government of Nunavut, Department of Community and Government Services, Kitikmeot Region to provide engineering consulting services for the Cambridge Bay Waste Facility Improvements project (GN Project No. 04-4807).

A planning report was prepared and issued in July 2006 by Earth Tech. A series of potential waste management areas were identified and discussed in that report. The planning analysis of the potential new sites included a "proximity" analysis of human activities and natural features; an analysis of potential road access to each site; an estimate of capital and operation and maintenance costs; and general site development configurations for the sites.

Water sampling of the existing waste management facilities (lagoon and landfill) was also carried out to provide additional information to the existing sampling studies (1998 and 2003). A report on Wastewater Sampling Results was issued in August 2006, and suggested that the "lagoon system of treatment is working satisfactorily to reduce the concentration of sewage contaminants to the acceptable level prior to discharge into the environment (Cambridge Bay)". The report also suggested that the landfill runoff was a significant source of contaminants to the existing sewage lagoon discharge.

Based upon the input from the November 9, 2006 Community Meeting and the direction provided by the Government of Nunavut, Earth Tech had proceeded with preliminary engineering for redevelopment of the existing sewage treatment and solid waste management. The preliminary engineering reports for redevelopment of the existing sewage lagoon and for solid waste site improvement were prepared and issued in April and June 2007 by Earth Tech.

In support of advancing the redevelopment of the existing waste management sites, a topographical survey and a geotechnical investigation of the sites were undertaken in the fall of 2006. The topographic survey generated accurate contour information for the landfill and lagoon pond areas, and the discharge stream; the geotechnical investigation provided information on the soil conditions around the sites, and information on the soil materials around the community that may be used for the construction of any redevelopment work. The geotechnical report also provided detail recommendation regarding berm construction. The geotechnical report is included in **Appendix B**.

1.2 Project Objectives

The following are the project objectives related to this report:

1. To provide a detailed engineered design and cost estimates for the redevelopment of existing sewage lagoon that can accommodate the sewage generated from the community for the next twenty (20) years (2007-2026).
2. To provide a detailed engineered design and cost estimates for the redevelopment of existing landfill site that can extend the life of the existing site to accommodate the solid waste generated from the community.
3. To incorporate improvements for waste disposal to divert waste at the redeveloped site.
4. To incorporate improvements for sewage treatment to reduce potential public health and environmental impacts.

5. To eliminate existing metal dump impact on the sewage lagoon discharge.
6. To provide a basis for a submission to the Nunavut Water Board for approval of the improvements.

2.0 COMMUNITY INFORMATION

2.1 Location and Access

The community of Cambridge Bay, the largest community in the Kitikmeot Region, is geographically situated on the Dease Strait between the Queen Maud Gulf and the Coronation Gulf in the North West Passage. It is located on 69° 07' N Latitude and 105°03' W longitude, and it is approximately 960 air km north east of Yellowknife and 1700 km east of Iqaluit.

Cambridge Bay can be reached by air from southern Canada. The community receives scheduled B737 jet service seven (7) days a week from Edmonton and Yellowknife via First Air and Canadian North airlines. Cambridge Bay can also be reached by sealift in summer from the Hay River in mid July.

It is one of the most westerly communities of Nunavut, with a population of 1,609 in 2006 (Nunavut Bureau of Statistics, 2006). Recent population figures for the community point to higher than normal growth.

2.2 Topography and Geology

The Hamlet of Cambridge Bay is situated in an area of sags and swells, dry debris-strewn knolls, and moist depressions, with very little vegetation (Canadian Arctic Profiles – Indigenous Culture, 2006).

Cambridge Bay is situated in an area of continuous permafrost. The reported ground temperature below 3 m depth averages about –9 ^{o}C. The thickness of active layer varies from 0.3 m in poorly drained areas to over 2 m in well-drained areas. Excess ice contents of up to 10% have been reported in the subsurface soils. The bedrock geology of the Cambridge Bay area comprises Paleozoic sedimentary rocks (carbonates, shales and sandstones). Bedrock is generally exposed at sporadic locations close to sea level. Where exposed, the bedrock comprises layers of dolomite and shale, and is jointed and frost shattered. Shale was the bedrock type observed at potential borrow sources during this site investigation (EBA, 2006).

2.3 Climate

The climate can be characterized by long cold winters and short cool summers. The daily average temperature is -14.4°C. The average total annual precipitation is 13.88 cm; consists of 82.10 cm of snowfall and 6.96 cm of rainfall. The average snow depth is measured as 15.0 cm. The July mean high is 12.3°C and mean low is 4.6°C. The January mean high is -29.3°C and mean low is -36.3°C. The prevalent wind direction is to the northwest at an annual average wind speed of 21.2 km/h (Canadian Climate Normals 1971-2000).

2.4 Population Projection

According to the Statistics Canada (2001 Census) the population of the Hamlet of Cambridge Bay in 2001 was 1,309; 4.89% of the population of Nunavut territory (Nunavut Bureau of Statistics – News Release on March 12, 2006). According to the Nunavut Bureau of Statistics' Community Population Projections 2000-2020, the population of Cambridge Bay in 2006 is 1,609.

Table 1 shows the population projection (2006 to 2020) by the Nunavut Bureau of Statistics.

Table 1 – Population Projection for the Hamlet of Cambridge Bay, 2006 - 2020

Projection Year	Projected Population
2006	1,609
2007	1,642
2008	1,679
2009	1,715
2010	1,752
2011	1,790
2012	1,828
2013	1,865
2014	1,900
2015	1,939
2016	1,979
2017	2,018
2018	2,057
2019	2,095
2020	2,137

Note:
An annual average population growth rate of 2.01% is calculated from the census information for the period 2006 - 2020.

2.5 Socio-Economic Activities

According to the 2004 "Hamlet of Cambridge Bay Community Economic Development Plan" (Polar Bligh Consulting, 2004), Cambridge Bay is a very progressive community with unlimited potential. It is expected that, being the hub of Kitikmeot Region, the community will experience a substantial economic growth in future years. The proposed port, road, health center projects, and mining ventures, will increase social and tourism activities in the community. However these activities may put burden on existing infrastructure.

3.0 EXISTING SERVICES

3.1 Water Supply and Distribution

The water use and waste disposal in the Hamlet of Cambridge Bay is regulated by a Type B Water License. The present source of the community's potable water source is Water Lake located approximately 3 km north of the community. A fill station is located in the community center and a water truck is used to distribute water to houses in the community. Water use from Water Lake totals 20 truckloads per day (12000 L per truckload). The current water consumption is approximately 87,600 m^3/year, although the current water license allows for the removal of 70,000 m^3 of water from Water Lake annually.

3.2 Sewage Collection and Disposal

Sewage is colleted from the community by tanker trucks, and discharged into a sewage lagoon system which is used to treat wastewater for the community. Currently, on average 16 truckloads (12,000 L per truckload) of sewage are discharged into the lagoon each day.

The existing lagoon has been in use for over thirty years. It is located approximately 1.5 km north east of the community and adjacent to the existing Waste Metal Disposal Site. The current system consists of several natural ponds connects in series (Pond 1, Pond 2, Pond 3, Pond 4, Pond 5 and Pond 6). The lagoon volume is approximately 72,000 m^3 based on the normal water level in the lagoon ponds (IEG, 2006). The sewage is discharged into Pond 1 of the lagoon by tanker trucks at truck discharge site. The treated sewage by the lagoon is channeled into Cambridge Bay. Currently, there is no discharge control structure in the lagoon. The existing lagoon is, therefore, seasonally flooded due to spring runoff flowing into the lagoon from the surrounding watershed. The sewage effluent from the lagoon is discharged to Cambridge Bay continually.

There are several issues of concern with the system. The main concern is the influence of large spring runoff flows on the lagoon. The storage and treatment capacity of the lagoon is reduced due to the flooding.

The other issues with the lagoon include:

1. The solid waste and waste metal dumps are immediate adjacent to Pond 1. There is a concern that runoff from the disposal site may be entering the ponds.
2. The culvert under a roadway along the system's discharge route has been known to freeze, causing the lagoon discharge to flood the road.
3. Concerns have been raised with the lagoon capacity to meet the needs of community growth over the next twenty (20) years.
4. The ice gathering area for the residents is in proximity to where the lagoon discharges to the Bay.

3.3 Sewage Sample Analysis

"Cambridge Bay Waste Facility Improvements Sewage Analysis – Summary Report" was prepared by Earth Tech in August 2006. The report summarized the results of sewage lagoon system samples collected in 1998, 2003, and 2006 and provides an overview of sewage characteristics and the treatment efficiency of the existing sewage lagoon system.

The results showed that the concentration of all the effluent discharge parameters (contaminants) collected from "Lagoon" and "Pond" sampling points were below the respective MWWE Guidelines in all three samples (1998, 2003 and 2006). The sampling results of "Outlet" sampling point show that the concentration of most of the effluent discharge parameters is below the MWWE Guidelines with the exception of pH, Al_{total}, and Fe_{total}.

The overall sampling results suggested that the lagoon system of treatment is working satisfactorily to reduce the concentration of sewage contaminants to the acceptable level prior to discharge into the environment (Bay).

The sampling results also suggested that the landfill runoff is a significant source of contaminants. Improvements to the landfill should, therefore, include runoff management to divert offsite runoff away from the site and collect onsite runoff for a controlled discharge.

3.4 Solid Waste System

There is no record of any previous solid waste sites in the Hamlet; it can be assumed that the current site has been in use for over thirty (30) years. The existing solid waste facility (site) is a typical northern landfill system that was developed as a matter of convenience with limited "engineering" of the waste disposal areas.

The municipal solid waste (MSW) area is adjacent to the west side of the sewage lagoon and the facility is not fenced, therefore wind-blown litter is a concern. The cut and fill or trench method was used to operate the MSW site until the mid-1990s. Since then the solid waste has been deposited throughout the landfill area and burned when the prevailing winds are away from the community. The burned wastes are covered with granular material periodically (IEG, 2005).

The existing metal dump area is immediately adjacent to the east side of the sewage lagoon. The current metal dump site consists of a pile of waste metal and other bulky wastes. Two smaller piles of waste metal were also found outside the metal dump area. One pile is at the opposite side of the sewage lagoon, which contains primarily large equipment, vehicles, and barrels. The other pile is across from the sewage pond where the truck discharges sewage, and it contains primarily barrels, oil burning furnaces, structural steel, and a large generator dated 1959.

The limited control and limited management presents a public health and environmental concern particularly in spring and summer for MSW site. In the absence of an operation and maintenance (O&M) manual, the Hamlet has no control over who dumps, what type of waste is dumped, or where it is dumped. A similar situation exists for metal dump area.

4.0 WASTE CHARACTERISTICS AND QUANTITY

4.1 Sewage Characteristics

Wastewater generated in Cambridge Bay is primarily domestic in source and characteristics. The wastewater quality from the community may be considered to be a "high strength" waste because of the use of a trucked sewage and water system. The "high strength" condition is typical for trucked sewage and water systems due to the low water usage which translated into low dilution of the raw sewage. The expected raw sewage characteristics for a high strength raw sewage would be 600 mg/L for BOD, 725 mg/L for TSS, and 10^7 coliforms/100 mL for Total Coliforms (NWT Water Board, 1986).

4.2 Effluent Guidelines

The Hamlet of Cambridge Bay's current water license stipulates the effluent requirement. The current water license came in effect on September 1, 2002 and expires on August 31, 2007. The conditions applying to waste disposal are stipulated in Part D of the license and are as follows:

1. The Licensee shall direct all piped and pump out sewage to the Sewage Disposal Facilities or as otherwise approved by the Board.
2. All Effluent discharged from the Sewage Disposal Facilities at "Surveillance Network Program" Station Number CAM-3 shall meet the following effluent quality standards:

Table 2 - Effluent Quality Standards

Parameter	Maximum Average Concentration
Faecal Coliforms	1×10^6CFU/dl
BOD_5	100 mg/L
Total Suspended Solids	120 mg/L
Oil and grease	No visible sheen
pH	Between 6 and 9

3. A Freeboard limit of 1.0 meter, or as recommended by a qualified geotechnical engineer and as approved by the Board, shall be maintained at all dykes and earth fill structures associated with the Sewage Disposal Facilities.
4. The Licensee shall advise an Inspector at least ten (10) days prior to initiating any decant of the sewage lagoon.
5. The sewage lagoon shall be maintained and operated in such a manner as to prevent structural failure.
6. The Licensee shall maintain the Sewage Disposal Facilities to the satisfaction of an Inspector.
7. The Licensee shall dispose of and contain all solid wastes at the Solid Waste Disposal Facilities or as otherwise approved by the Board.
8. The Licensee shall implement measures to ensure hazardous materials and/or leachate from the Solid Waste Disposal Facility does not enter water.

4.3 Sewage Quantity

Based upon population projection by the Nunavut Bureau of Statistics the generation of sewage waste is estimated for the next twenty (20) years (starting from 2006).

Table 3 presents the summary of sewage generation in the next 20 years.

Table 3 - Estimated Sewage Waste Volume Generation for the Hamlet of Cambridge Bay, 2006-2025

Planning Year	Year	Population	Daily Sewage Waste Volume, m^3/d	Annual Sewage Waste Volume, m^3/yr
1	2006	1,609	225	82,220
2	2007	1,642	230	83,906
3	2008	1,679	235	85,797
4	2009	1,715	240	87,637
5	2010	1,752	245	89,527
6	2011	1,790	251	91,469
7	2012	1,828	256	93,411
8	2013	1,865	261	95,302
9	2014	1,900	266	97,090
10	2015	1,939	271	99,083
11	2016	1,979	277	101,127
12	2017	2,018	283	103,120
13	2018	2,057	288	105,113
14	2019	2,095	293	107,055
15	2020	2,137	299	109,201
16	2021	2,180	305	111,390
17	2022	2,223	311	113,618
18	2023	2,268	318	115,890
19	2024	2,313	324	118,208
20	2025	2,360	330	120,572

Notes:
1. Population projection data (2020-2025) based on 2% growth rate (determined from GN population projection data).
2. Population projection data (2020-2025) extrapolated by Earth Tech.
3. Average daily sewage waste generation rate per person is 140 liters (Reference – IEG, 2005).

4.4 Solid Waste Characteristics

4.4.1 MSW Site

Typically Nunavut communities' MSW sites contain primarily bagged household wastes and a few household hazardous wastes such as paints, solvents, waste oil or batteries, etc. The Hamlet of Cambridge Bay's MSW area appears to contain all of these waste components; however, there is more industrial activity in Cambridge Bay compared to the majority of Nunavut communities, and it appears DEW Line era wastes may be disposed at the site (IEG, 2005).

4.4.2 Metal Dump Site

The current metal dump site consists of some unsegregated bulky wastes and waste metal including vehicles, heavy equipment, barrels, steel from burnt high school, white goods, fuel tanks, and other waste metal.

4.5 Solid Waste Disposal Site Review

The existing solid waste disposal site has raised some concerns such as: the site is not fenced; wind-blown litter is a problem; municipal solid waste is not covered on regular basis; municipal solid waste is burned; uncontrolled access to the site is allowed. Runoff from the site is not controlled; and no O&M documentation exists.

4.6 Solid Waste Quantity Projection

According to the 2003 Guidelines for Planning, Design, Operations and Maintenance of Modified Solid Waste Sites in the NWT, the new landfills should be planned based on a 40 year planning horizon.

Based upon population projection by the Nunavut Bureau of Statistics the generation of solid waste is estimated for the next 40 years (starting from 2006).

Table 4 presents the summary of waste generation in the next 40 years, and **Table 5** shows the waste type and its generation rate.

Table 4 - Solid Waste Volume Projection for the Hamlet of Cambridge Bay, 2006 – 2045

Planning Year	Year	Population	Annual Uncompacted MSW Volume, m^3/yr	Total MSW Volume, m^3	Compacted MSW (3:1), m^3
1	2006	1,609	12,379	12,379	4,126
2	2007	1,642	12,701	25,080	8,360
3	2008	1,679	13,050	38,130	12,710
4	2009	1,715	13,399	51,529	17,176
5	2010	1,752	13,760	65,290	21,763
6	2011	1,790	14,133	79,423	26,474
7	2012	1,828	14,513	93,935	31,312
8	2013	1,865	14,893	108,828	36,276
9	2014	1,900	15,269	124,098	41,366
10	2015	1,939	15,675	139,773	46,591
11	2016	1,979	16,095	155,868	51,956
12	2017	2,018	16,516	172,384	57,461
13	2018	2,057	16,946	189,330	63,110
14	2019	2,095	17,379	206,709	68,903
15	2020	2,137	17,843	224,552	74,851
16	2021	2180	18,320	242,872	80,957
17	2022	2223	18,812	261,684	87,228
18	2023	2268	19,319	281,002	93,667
19	2024	2313	19,841	300,843	100,281
20	2025	2359	20,379	321,222	107,074
21	2026	2407	20,933	342,155	114,052
22	2027	2455	21,505	363,660	121,220

Planning Year	Year	Population	Annual Uncompacted MSW Volume, m^3/yr	Total MSW Volume, m^3	Compacted MSW (3:1), m^3
23	2028	2504	22,094	385,754	128,585
24	2029	2554	22,701	408,455	136,152
25	2030	2605	23,328	431,783	143,928
26	2031	2657	23,973	455,756	151,919
27	2032	2710	24,639	480,395	160,132
28	2033	2764	25,326	505,721	168,574
29	2034	2820	26,034	531,755	177,252
30	2035	2876	26,764	558,519	186,173
31	2036	2934	27,518	586,037	195,346
32	2037	2992	28,296	614,332	204,777
33	2038	3052	29,098	643,430	214,477
34	2039	3113	29,926	673,356	224,452
35	2040	3175	30,780	704,136	234,712
36	2041	3239	31,662	735,797	245,266
37	2042	3304	32,572	768,369	256,123
38	2043	3370	33,511	801,881	267,294
39	2044	3437	34,481	836,362	278,787
40	2045	3506	35,483	871,845	290,615

Notes:

New landfills should be planned based on a 40 year planning horizon (NWT Guidelines, 2003).

Population projection data (2006-2020) from "Nunavut Bureau of Statistics".

Population projection data (2021-2045) based on 2.01% growth rate (determined from GN population projection data, 2006-2020).

Uncompacted MSW Volume, $m^3/yr = 365\ V\ P_n\ (1+G) + 0.084\ V\ P_1^2\ (1+G)^{2n}$ (NWT Guidelines, 2003).

V = average MSW volume (m^3/person/day); 0.015 m^3/person/day (FSC, 2000)

P_1 = Population in current year (number of persons served)

Pn = Population in nth year (persons);

G = average population growth rate (persons/year); 0.02/year.

Compaction ratio 3:1 for Compacted Landfill Site (NWT Guidelines, 2003).

Table 5 - Solid Waste Types and Estimated Volumes for the Hamlet of Cambridge Bay

Solid Waste Type	% Contributing	Design Period		
		40 years	20 years	10 years
		Total Compacted Solid Waste Generation (m^3)		
		290,615	107,074	46,591
Food Wastes	20.3	58,995	21,736	9,458
Cardboard	9.8	28,480	10,493	4,566
Newsprint	2.4	6,975	2,570	1,118
Other Paper Products	14.8	43,011	15,847	6,895
Cans	4.4	12,787	4,711	2,050
Other Metal Products	6.2	18,018	6,639	2,889
Plastic, Rubber, Leather	14.0	40,686	14,990	6,523
Glass, Ceramics	5.7	16,565	6,103	2,656
Textiles	3.8	11,043	4,069	1,770
Wood	9.9	28,771	10,600	4,613
Diapers	3.8	11,043	4,069	1,770
Dirt	4.9	14,240	5,247	2,283
Total	100	290,615	107,074	46,591

Note:
1. Waste composition is obtained from 2003 Guidelines for Planning, Design, Operations and Maintenance of Modified Solid Waste Sites in the NWT, for a typical modified landfill (solid waste facility) in the northern communities.
2. It is estimated that honey bags and animal carcasses to be 1% of the total volume, and hazardous wastes to be 2% of the total volume.

5.0 SEWAGE LAGOON IMPROVEMENTS

The sample results indicated that the concentration of the effluent discharge parameters is below the concentration required by Water License. The sampling results suggest that the lagoon system of treatment is working satisfactorily to reduce the concentration of sewage contaminants to the acceptable level prior to discharge into the environment. The existing lagoon system may still serve the Hamlet as a sewage treatment facility for the next twenty (20) years with improvements which address the issues of concern regarding the current operation (See **Drawing C03** in **Appendix A)**

5.1 Design Criteria

Design Treatment Capacity: 120,000 cubic meters per year [twenty (20) year horizon]

Current Design Effluent Quality Based Upon Nunavut Water Board Guidelines:

Faecal Coliforms	1 x 10^6CFU/dl
BOD5	100 mg/L
Total Suspended Solids	120 mg/L
pH	Between 6 and 9

Future (2025) Design Effluent Quality Based Upon Wetland Treatment (See Appendix C):

Faecal Coliforms	100 CFU/dl
BOD5	18 mg/L
Total Suspended Solids	16 mg/L
Total Phosphorous	2.2 mg/L
Ammonia Nitrogen	9 mg/L
pH	Between 6 and 9

Lagoon Pond Area: 14.5 hectares

Average Active Depth: 1.33 meters (ranges from 0 to 3.5 m)

Storage Volume: 190,000 cubic meters

Freeboard: 1.0 m

High Water Level: 10.00 m

Discharge: Annually

Discharge Duration: three (3) weeks, from mid-August through early September

Polishing Treatment: Wetland

5.2 Capacity Increase

The current sewage generation rate is approximately 70,080 cubic meters per year. The existing high water level of the lagoon is approximately 8.85 m. On the basis of hydraulic retention time (HRT), the current lagoon may achieve a HRT of approximately 375 days based on the current sewage generation rate. This is based on a rough volume estimate of 72,000 cubic meters for the existing lagoon storage. This HRT achieves the maximum benefit from retention during the limited summer season.

By the year of 2025 the sewage generation rate would be approximately 120,000 cubic meters per year. The HRT would be reduced to approximately 219 days. A 219 day HRT may not achieve the maximum benefit from complete sewage retention during the limited summer season (June, July, and August) resulting from solar energy, and biological activity. The lagoon retention volume can be increased by increasing the high water level. A water level elevation of 9.5 m at Pond 1 would provide a lagoon volume of 119,000 cubic meters. The HRT would be approximately 360 days. The water level of 10.0 m would provide a storage volume of 190,000 cubic meters which would efficiently handle the precipitation and limited off-site runoff.

The increased water level of 10.0 m would be achieved by construction of new retention berms and reinforcement of existing berms. **Drawing C04** in **Appendix A** shows the lagoon improvement plan regarding the berm construction and reinforcement. 1.0 meter of freeboard is proposed for the improved lagoon. Detail discussion regarding the berm construction was included in the Geotechnical Evaluation for Municipal Waste Facilities Cambridge bay, NU (December, 2006) prepared by EBA Engineering Consultants Ltd (See **Appendix B**).

A 220 meter long of retention berm is proposed between existing Pond 2 and Pond 3. The top elevation of the berm is proposed 11.00 m. The existing berm between the landfill site and the existing lagoon will be enforced into the supplementary retention berm with the top elevation of 11.00 m. Part of the supplementary retention berm will be connected to the landfill site road to form the access to the lagoon decant access. After the improvement, Pond 1 and Pond 2 would be the sewage treatment cells. Pond 3 would be developed into a portion of a wetland The proposed wetland (see **Drawing C04**) would polish the effluent from the improved lagoon (Pond 1 and Pond 2) before it enters to the environment (Cambridge Bay). The improved lagoon is designed as a seasonal discharge lagoon. The treated sewage would be discharged once a year in the late summer.

5.3 Primary Cell

In order to improve the lagoon performance, a primary cell is proposed at northwest of the Pond 1 (see **Drawings C01 and C04**). An approx. 60 m long of submerged berm with top elevation of 9.0 m is proposed to separate primary cell and secondary cell. Much of the suspended solids are expected to be settled within the primary cell before sewage enters the secondary cell. The sludge settled in primary cell could be removed on a periodic basis.

5.4 Discharge Flume

The discharge flume will be located at the west end of the primary cell. The sewage truck will use the discharge flume to deposit raw sewage into the primary cell. There will be a treated lumber wheel stop and bollards at the edge of the pad to prevent the truck from backing into the sewage lagoon. From the truck pad, the offload chute consisting of an 800mm diameter nestable culverts will run down the inside slope of the berm to the rip rap field at the bottom of the lagoon. The discharge flume and truck pad are detailed in **Drawing C06**.

5.5 Decant System

The mobile decant system will be located at the opposite end of the lagoon to the truck discharge flume during lagoon decant period (see **Drawing C04**). The lagoon will be annually discharged by pumping effluent into the proposed wetland from the lagoon using a pump and a seasonal decant line. Given the maximum lagoon storage volume of 190,000m3 and, a mobile Gorman Rupp diesel engine driven pump package, model T6A60S-3054C is proposed to decant the lagoon annually over a period of three weeks.

5.6 Spillway

A spillway is proposed in order to control the lagoon high water level and protect the berms in the event of an extreme runoff situation. Any water above high water level (10.0 m) would overflow through the spillway on the proposed retention berm. **Drawing C06** shows the details of the spillway.

5.7 Polishing Wetland

An engineered wetland is proposed to further treat the effluent from the lagoon system. **Drawing C04 and Appendix C)** identifies the proposed wetland area. The area of the wetland is approx. 2.8 hectares. Water quality would be improved through a variety of natural processes that occur in wetlands. The technology of seasonal discharge from a lagoon to wetlands has been demonstrated to provide significant sewage treatment capabilities. Using natural filtration, sedimentation, and physical or chemical immobilization, the soil and plants of wetland systems effectively absorb and retain suspended solids, carbonaceous and nitrogenous components of BOD, nutrients, pathogenic organisms, and other pollutants.

5.8 Discharge Route

The proposed effluent path is shown in **Drawing C01 and C04**. The effluent will be diverted around the bulky metal dump site via a proposed approximately 500m long isolation berm along west side of the metal dump site. The effluent enters the engineered wetland before crossing under the existing road. A 400mm culvert running under the road will be required; from the culvert, the effluent will flow to the Bay.

The proposed discharge route would be 400 meters east of the existing discharge route. This changed route would avoid the conflict with the proximity to the community.

5.9 Runoff Diversion

One of the major concerns regarding the existing lagoon is the spring runoff flows into the lagoon. The performance and capacity of the lagoon is significantly influenced. Consideration of this concern suggests that runoff diversion berms would be required. The proposed runoff diversion berms are identified based on the watershed contours. The runoff diversion berms would divert most runoff around the lagoon (see **Drawing C04**). These runoff diversion berms complement the proposed isolation berm for the bulk metal area which will divert the runoff away from the landfill area.

5.10 Access Roads

The existing access road need to be extended approx. 350 meters to reach the truck discharge flume at northwest end of the primary cell. A turnaround area with 12 m radius is proposed at the truck discharge area. A 220 meter road is proposed on the top of the supplementary retention berm to connect the solid waste site to the lagoon decant location as an access road during lagoon decent.

6.0 SOLID WASTE DISPOSAL SITE REDEVELOPMENT

A variation on the existing solid waste site is proposed for the disposal/management of solid waste. Because of the expected permafrost and shallow bedrock, the solid waste site operation should be restricted to an area fill method. A number of improvements are proposed to manage the existing site in an organized manner so that the capacity (design life) of the existing site may be increased.

The proposed configuration requires the development of designated areas within the site to be used for disposal of specific types of wastes. This will help in the disposal of the waste depending upon its type, and will also help in organizing the area within the site boundary. **Drawing C07** presents the proposed site development concept. The area within the site has been partitioned for honey bag waste and carcasses, plastic waste (including tires), hazardous waste, and MSW areas. The existing metal dump site will still be used for metal dump after the isolation berm between the lagoon and the site is built.

The proposed improvements also include runoff management to divert off-site runoff away from the site and collect on-site runoff for a controlled discharge. Such improvements may require a slope to the north at the north end of the access road, which can be achieved by partially regrading the site.

The use of an advancing active face within one of the four cells of the site will simplify the operation and organization of the solid waste site. Temporary fencing may be utilized to restrict the dumping area and allow the active face to advance section by section. This will promote optimal use of cover material to provide the future driving surface as well as optimal opportunity for compaction. The height of the active face should be maintained at one (1) meter or less to accommodate access for compaction. The cells should be developed in sequence – Cell 1 followed by Cell 2, etc.

6.1 Setbacks

The setback criteria for the various features are based upon various guidelines:

Government of the Nunavut Public Health Act and General Sanitation Regulations require that the existing site maintains a minimum 450 meters from areas of human habitation (community) and a minimum 90 meters setback to major roadway. The existing site is 1.0 kilometer away from the community.

Transportation Canada recommends a minimum 8 kilometers setback between a solid waste disposal site (food wastes) and an airport. This setback can not be achieved on the proposed site; however, Transport Canada has relaxed this setback guideline to minimum 3 kilometers setback for the northern territories (Government of the Northwest Territories, NWT, 1990). The 3 kilometers set back guideline can be achieved on this site.

6.2 Access Road

Access for the site redevelopment is based upon the existing access road in the landfill site upgraded to a 6 m driving surface with a turnaround point at the end of the working area. Accesses to MSW cells are also proposed. The access road is also connected to the proposed access road to lagoon decant location. The access road should be constructed with suitable granular material to provide an all-season driving surface for heavy vehicles/equipment.

6.3 Site Drainage

The proposed improvements also include runoff management to divert offsite away from the site and collect on-site runoff for a controlled discharge shown on **Drawing C07**. The existing solid waste site naturally slopes from south to north. The site could be partially regraded to achieve the designed slope and elevation shown in **Drawing C07**. Perimeter ditches (see **Drawing C08** for detail) are proposed on-site along the access road and berms to collect the on-site runoff. The on-site ditches will convey the on-site runoff to a runoff detention pond which is a low area at north of the site. The pond will provide detention before the runoff is discharged to the lagoon system by a mobile pump (lagoon decant pump) periodically (see **Drawing C08**). The off-site ditches will divert the off-site runoff away from the landfill site.

6.4 Site Storage Volume

Table 5 identifies a total solid waste volume generation of 107,000 m^3 for 20-year planning horizon (assuming a compaction ratio of 3:1), which includes 95,700 m^3 of MSW and 11,300 m^3 of waste metal and bulky waste. Assuming an average depth of 2 m, approximately 47,850 m^2 and 5,650 m^2 of areas (excluding additional operating areas required for waste diversion) are required for MSW site and metal dump site twenty (20) year planning horizon.

The existing MSW site (approximately 28,000 m^2) is not capable of meeting the area requirement for twenty (20) year planning horizon. However, the capacity of the existing site can be increased to accommodate the MSW volume generation over the next 10 years (2006-2016) i.e. 42,000 m^3. The current metal dump area may also accommodate the metal waste generation over the next ten (10) years after the isolation berm between the sewage lagoon and the site is built. The existing site may serve beyond the ten (10) year period following proposed improvements, but it depends upon volume reduction by employing segregation and recycling practices, and the management of the site according to the proposed operation and maintenance guidelines.

6.5 Fence

In general, fencing of a solid waste disposal site is practical for a number of purposes. A fence will provide a barrier to windblown material and a visual barrier to the site. A fence may also control unauthorized access to the site, thereby improving site management. Fences are proposed around the site except for the north side along the lagoon supplementary retention berm. The fence is proposed to be aligned on the shoulder of the existing lagoon access road along the west side of the site (see **Drawing C09** for detail). The fence along south and east of the site are proposed to be constructed on a 0.5m high berm (see **Drawing C08** for detail).

6.6 Municipal Solid Waste Cell Area

MSW cell area will store food wastes, paper wastes, glass, ceramics, and wood wastes. **Table 5** shows that 42,000 m^3 of MSW is expected to be generated in the next ten (10) years (2006-2016). Considering 2 m as MSW disposal cell's active height it is determined that an area of approximately 21,000 m^2 is required for MSW disposal. This area requirement is based upon the assumption that the community will follow the standard method of MSW disposal and compaction. **Drawing C07** shows the proposed four MSW cells. The total proposed MSW cells area is 23,000 m^2.

6.7 Honey Bag Disposal Area

The proposed honey bag disposal area will be located to the northwest corner of the site. It was estimated that honey bags and animal carcasses to be 1% of the total volume. The total volume of honey bag waste generated over the ten (10) year planning horizon is 466 m^3, and similar volume will be generated for animal carcasses. Assuming no phasing out of the honey bag waste in the next ten (10) years, the total volume required to contain the honey bag waste and animal carcasses is 932 m^3. Combining honey bag waste with animal carcasses, an area of 900 m^2 (with some allowance for fence/berm) would be appropriate to contain honey bag waste and animal carcasses.

The honey bag disposal area will be bermed with a 3 m wide top and 2 m deep. The side slopes to be 1 vertical and 3 horizontal. A deadman structure with identification signage should be constructed at the designated area.

Honey bag and animal carcasses represent a bio-hazardous waste material which should be isolated from the main waste disposal area. The honey bag area will accommodate covering of animal carcasses, on a regular basis, to reduce odour and prevent animal scavenging. Frequency of covering the honey bag area should be determined once the area is in operation. Covering during the winter may not be necessary because the waste materials are frozen and not a nuisance, whereas weekly covering may be necessary during the summer.

6.8 Hazardous Waste Area

Hazardous waste in northern communities represents approximately 2% of the total. The predominant materials are oils and grease and household hazardous wastes. Given the small quantity, storage of the materials for ultimate removal in future may be a good way to address the problem. This approach is being pursued by many other communities including Iqaluit. The hazardous waste area should be lined to minimize the potential infiltration to the active layer.

6.9 Metal Dump Area

An isolation berm is proposed to separate the existing metal dump area and sewage lagoon. After the isolation berm is built, the impact on the sewage lagoon discharge will be minimized, therefore, the existing metal dump area can still be used as metal dump area. Further consideration may be given to crushing and burying the existing metal waste.

7.0 OPERATION AND MAINTENANCE OF SOLD WASTE DISPOSAL SITE

7.1 Active Areas within Site

The active areas of the solid waste disposal site should be as small as possible. This is important in providing a manageable and safe disposal site for the public and operating staff. If limited burning is used for wood waste material, the area for burning requires particular attention because of the potential fire hazard.

7.2 Compaction

Compaction will be necessary as the working face of the disposal area advances from the access road in order to prepare a drivable area for vehicles. This compaction could be accomplished by heavy equipment such as a bulldozer on weekly or bi-weekly basis, during the summer.

7.3 Waste Covering

Three types of cover may normally be used in a solid waste disposal site: daily cover, intermediate cover, and final cover. For the solid waste site redevelopment in Cambridge Bay, the limited availability of cover material dictates that daily cover may not be possible. This will be determined once the redeveloped site begins operation.

Intermediate cover is normally used when portions of a solid waste site are expected to remain open for a long period of time. In the case of Cambridge Bay solid waste site, intermediate cover may be used to create a drivable surface as the working face of the solid waste disposal area advances. Final cover is utilized to minimize infiltration of water into the solid waste material once waste disposal on the site is ceased. A multi-layer configuration is used for cover in which each layer has a distinct purpose. The first layer, closest to the solid waste, should consist of a granular material which is used to grade the site to provide drainage off the surface (a minimum 3% slope). The second layer is a barrier layer which provides a barrier for water infiltration into the solid waste material. This layer may consist of clay or amended soil (bentonite or similar material added). Since clay is scarce in Cambridge Bay, and an amended soil may be difficult to achieve, therefore the appropriate material may be the existing poorly draining silty sand.

7.4 Fire Control and Protection

Fire control is an important part of the operation of a solid waste disposal site which uses burning to reduce volumes. Burning control practices should include:

- Presence of an attendant on the site while the fire is in its initial stages followed by periodic inspection.
- Providing a minimum buffer zone of 5 m around the burning area.
- Maintaining a reasonably small combustion area.
- Restricting public access to the burning area.

7.5 Snow Accumulation

Snow accumulation can be a problem for day to day operation, as well as long term effectiveness for solid waste disposal sites. Snow accumulation may hinder day to day access to a site because of snow drifting. For the proposed site development, most of the access road is perpendicular to the prevailing winds, therefore snow drifting may be minimized. However, snow disposal within the site may require some organization to avoid conflicts between snow disposal areas and active waste disposal areas.

Snow accumulation within the solid waste itself may reduce the volume available on site for disposal. Snow may mix the solid waste and remain frozen once the waste is covered. To collect snow on the solid waste site for smooth operation of the site an area of 500 m^2 is allotted on the site.

7.6 Litter Control

Paper and other lightweight material may create littering problems around the solid waste site. The orientation of the access road should reduce wind blown material.

A reasonably well maintained site free from litter should have a positive effect upon users of the site. This may translate into efforts to utilize the site in an organized manner.

7.7 Dust Control

Controlling dust in the solid waste disposal site may be difficult. The heavy traffic may create dust problems within the site because of dry road material; watering the road may reduce dust, but it may also increase runoff within the site if not used in proper quantity. Site experience must be used regarding the quantity of water applied to the access road to reduce dust. A road treatment such as calcium chloride may also be used to stabilize the road surface.

7.8 Access Road Control and Maintenance

Access to the solid waste site should be controlled in a manner which is suitable to the Hamlet, and the residents. Regular operating hours and closure of the site with the use of a gate may or may not be successful. The end result with gate controlled access could be indiscriminate dumping near the access road; however, a container outside the gate could minimize this problem.

The access road for the solid waste disposal site should be maintained properly at all times. The frequent use of heavy equipment may cause the road to deteriorate significantly. Adequate road maintenance should include the following points:

- Maintaining drainage on road surface.
- Maintaining road surface reasonably free of ruts and potholes.
- Application of soil amending material to create a stronger driving surface.
- Maintaining a good granular base on the road.
- Checking regularly the access road to the solid waste site especially in winter to make sure accessibility to the site in winter.
- Monitoring the condition of the road by the operator, and keeping the maintenance crew/council informed of the situation as to snow clearing or grading requirement.

7.9 Directional Signs

Clear visible on-site directional signs should be posted for proper traffic routing on the site. The multilingual signs should identify the various areas of the site and the material to be deposited in each area.

7.10 Hazardous Waste

There are several factors to consider when storing hazardous waste. These factors include compatibility, segregation, ventilation, climate/environment, handling, security, and record keeping.

7.10.1 Compatibility

The compatibility between different types of wastes must always be considered before storage. The compatibility of wastes with their containers must also be considered. For example, acids should not be stored in steel drums, and some hydrocarbons cannot be stored in plastic containers. The compatibility of wastes with nearby materials and equipment is also very important, particularly when dealing with flammable wastes.

7.10.2 Segregation

The final destination of wastes should always be considered before storage. If recovery may be possible in the future, wastes should be stored in a manner that will allow such recovery.

7.10.3 Ventilation

Hazardous wastes should be well ventilated. Highly volatile organics in particular can present a serious health hazard in storage. If possible, most wastes should be stored outside in shed which provides free air movement.

7.10.4 Climate/Environment

Not all hazardous wastes should be stored outside. For example, flammable wastes stored outside in drums during a hot summer can buildup pressure and damage the container. Wastes with a high water content can experience freeze/thaw cycles and eventually crack and leak.

If stored outside, containers should be covered by a roof or tarpaulin, and preferably placed on an impermeable base. This prevents contact of rainwater and soil, keeps off the direct sunlight, and makes clean-up of any spills or leaks easier and cheaper. The area should be curbed or diked to collect spills, leaks, and precipitation. This containment area should be capable of holding at least 10-15% of the total volume of the stored product.

7.10.5 Handling and Security

The WHMIS (Workplace Hazardous Materials Information Sheet) guidelines should be followed in all cases when handling hazardous materials. These guidelines are legally enforceable throughout Canada.

Security precautions are necessary to avoid theft, accidental discharge, or harm to the public.

7.10.6 Record Keeping

Records must be maintained to achieve safe hazardous waste storage. If quantities and types of wastes are not recorded, serious problems may result in the future. Care should be taken to ensure that containers remain properly labeled during the entire time in storage.

7.11 Performance Monitoring

There are two purposes to monitor a solid waste disposal site. The first purpose is to find out whether a site is performing as designed, which will provide an early indication if problems develop so that corrective action can be taken before problems become unmanageable. The second purpose is to judge whether the site is conforming to regularly requirements.

The design performance should include routine inspections and judgment on the site development features in reflection of the intended design performance. Action to improve upon the development features should also be undertaken on a routine basis to improve the design performance.

The regulatory performance should satisfy the concerns of the various relevant regulatory agencies with regular monitoring and reporting as deemed necessary by these agencies. The regulatory performance monitoring may only include the sampling and analysis of the runoff (leachate) to determine the degree of contamination, if any. Any appropriate means of controlling the runoff discharge can then be determined upon consultation with the regulatory agencies.

7.12 Record Keeping

The record keeping for a solid waste disposal site is an important aspect to overall site operation and maintenance. The record keeping of the site may include:

- Date when garbage is being compacted.
- Final depth of compacted garbage above ground.
- Number of trips per week and number of vehicles.
- Number of hours per week of hauling garbage.
- Number of operators.

8.0 COST ESTIMATES FOR IMPROVEMENTS

The recommended improvements associated with the lagoon improvements include access road extension, runoff diversion, new berm construction, existing berm reinforcement, wetland development, and new outfall construction. A pre-tender cost estimate for the proposed lagoon redevelopment discussed in Section 5 is summarized in **Table 6.**

Table 6 – Pre-tender Cost Estimate for Lagoon Improvements

No.	Description	Estimated Cost
1	Retention Berms	$ 156,000
2	Submerged Berms	$ 19,500
3	Runoff Diversion Berms	$ 146,000
4	Isolation Berms	$ 183,000
5	Existing Berms Reinforcement	$ 195,000
6	Overflow Weir	$ 5,000
7	Truck Discharge Flume	$ 12,000
8	Decanting Equipment (Pump and Trailer)	$ 49,000
9	Wetland Development	$ 408,000
10	New Outfall	$ 22,000
11	Access Road Extension	$ 210,000
12	Existing Culvert Replacement	$ 21,000
13	Runoff Diversion Channel Excavation	$ 27,000
	Subtotal	$ 1,447,000
14	Contingency (25%)	$ 362,000
	Total	$ 1,809,000

The recommended construction associated with the improvements of the existing solid waste disposal site should include access road, site grading, berming bio-hazardous and hazardous waste areas, fencing, and signage. A pretender cost estimate for the proposed site development is presented in **Table 4**. The construction activities may be completed in the course of one construction season.

Table 7 – Pretender Cost Estimate for Solid Waste Disposal Site Improvements

Item No.	Item Description	Estimated Cost
1	Site Preparation	$ 200,000
2	Fence Supply & Installation	$ 44,000
3	Berms	$ 40,000
4	Road Improvement	$ 54,000
5	Signage (Signs)	$ 7,000
6	Drainage Ditches	$ 60,000

Item No.	Item Description	Estimated Cost
7	400 mm Culvert w/ Rip Rap	$ 60,000
8	On-site Runoff Retention Pond	$ 10,000
9	Operator's Shack	$ 10,000
10	Equipment Allowance	$ 150,000
11	Entrance Gate	$ 2,000
	Subtotal	$ 637,000
12	Engineering & Contingency (25%)	$ 159,250
	Total	$ 796,250

9.0 CONCLUSIONS

9.1 Sewage Lagoon

The existing lagoon system appears to be functioning to reduce the concentration of sewage contaminants to the acceptable level prior to discharge into the environment. Therefore it is feasible to use the existing lagoon site with improvement regarding the current concerns.

It has been identified by Earth Tech that the cost of a new lagoon would be more than $3.7 million (refer to Planning Report for New Waste Management Sites, 2006). In comparison, it would cost approximately $1.8 million to improve the existing lagoon. Therefore, redevelopment of the existing site may be a more cost effective option if all the concerns regarding to the existing lagoon site configuration and operation are addressed properly.

The proposed improvement should solve or reduce the following concerns:

1. The ice gathering area for the residents is where the lagoon discharged to the Bay.
2. The lagoon capacity to meet the needs of community growth over the next twenty (20) years.
3. The influence of large spring runoff flows on the lagoon.

9.2 Solid Waste

Planning Report for New Waste Management Sites (Earth Tech, July 2006) suggested that it may took more than $1.5 million to develop a new solid waste disposal site due to the high cost regarding the construction of access roads. The redevelopment of the existing solid waste site with a cost of approximately $0.8 million would, therefore, be more cost effective option.

The proposed solid site improvement will be able to accommodate solid waste generated in next ten (10) year. The proposed areas for solid waste disposal may be improved in a way to effectively and appropriately handle municipal solid waste, bulky waste, bio-hazardous waste (honey bags and animal carcasses), and hazardous waste.

10.0 CONSTRUCTION RECOMMENDATIONS

10.1 Sewage Lagoon

The improvement of the existing lagoon system can be staged according to the priority of each portion of the improvements and construction feasibility. This will give the community a flexibility regarding the final issue.

The recommended construction sequence would be as follows:

1. Improve flow under the road along the existing discharge channel by replacing culverts to make sure that the culverts remain free of ice and debris (see **Drawing C05**).
2. Construct runoff diversion berms and runoff diversion channels to divert offsite runoff away from the lagoon (see **Drawing C03 and C01**).
3. Extend access road and build the truck discharge flume.
4. Build the submerged berm.
5. Build a temporary berm between Ponds 1 and 2 for construction of the new retention berm.
6. Build the new retention berms and the supplementary retention berm.
7. Construct the isolation berm beside the metal dump site.
8. Construct the new outfall.
9. Construct the engineered wetland.

Given the importance of the berms for the lagoon construction, it is recommended to have a geotechnical professional on site during berm construction.

10.2 Solid Waste Site

Given the proximity to the lagoon, it is recommended the solid waste site construction schedule be incorporated to the construction schedule of the lagoon. The solid waste site improvement will not complete until the isolation berm and the retention berms of the lagoon are completed.

11.0 REFERENCES

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